Chairman David Porter
Commissioner Christi Craddick
Commissioner Ryan Sitton

May 2016

STAKEHOLDER MEETING

NPS GRANT PROJECT UPDATE

Ballinger Seep Site

Ballinger, Texas

May 25, 2016

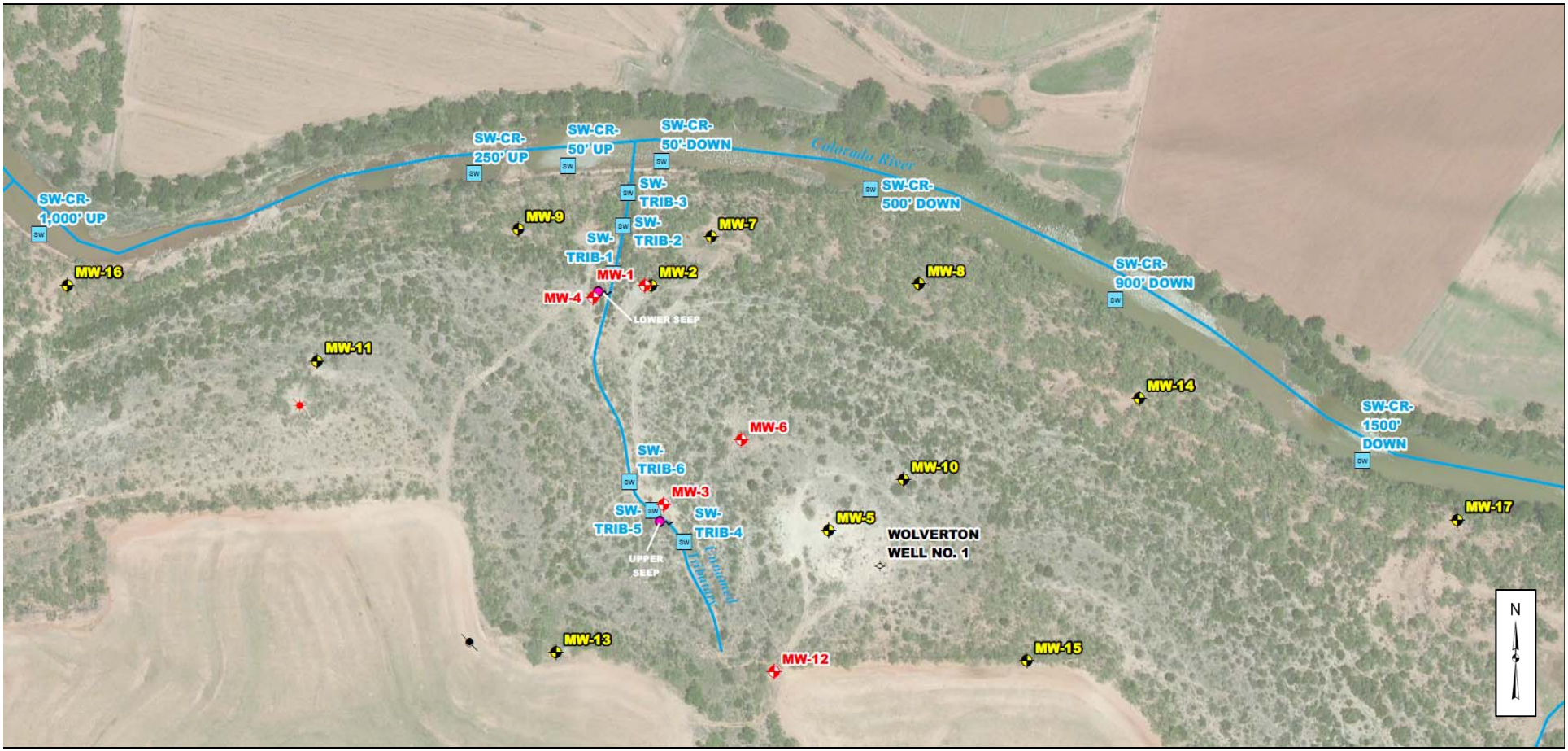
2013 NPS GRANT PROJECT OBJECTIVES

- Goal: Mitigate salinity loading to the Colorado River as a result of impacted groundwater beneath the site.
- Tasks:
  - Investigation of the optimum location for a Best Management Practice (BMP) system
  - Implementation of a BMP (i.e., saline groundwater recovery system)
  - Monitor BMP effectiveness

2013 NPS GRANT ACTIVITIES PERFORMED TO DATE

- Monitoring and Modeling Quality Assurance Project Plans (QAPPs).
- Comprehensive groundwater/surface water monitoring event in 2014 for current site data.
- Additional surface water sampling in June and December 2015.
- Aquifer testing in 2015 for site-specific hydrogeologic characteristics.
- Groundwater flow modeling and BMP scenario evaluation in 2015.
- Initial BMP design finalized May 2016.

SITE LAYOUT


SW-CR-1,000' UP
SW-CR-250' UP
SW-CR-50' UP
SW-CR-50'-DOWN
Colorado River
SW-CR-500' DOWN
SW-CR-900' DOWN
SW-CR-1500' DOWN
SW-TRIB-3
SW-TRIB-2
SW-TRIB-1
SW-TRIB-6
SW-TRIB-5
SW-TRIB-4
MW-1
MW-2
MW-3
MW-4
MW-5
MW-6
MW-7
MW-8
MW-9
MW-10
MW-11
MW-12
MW-13
MW-14
MW-15
MW-16
MW-17
LOWER SEEP
UPPER SEEP
Unnamed Tributary
WOLVERTON WELL NO. 1
N

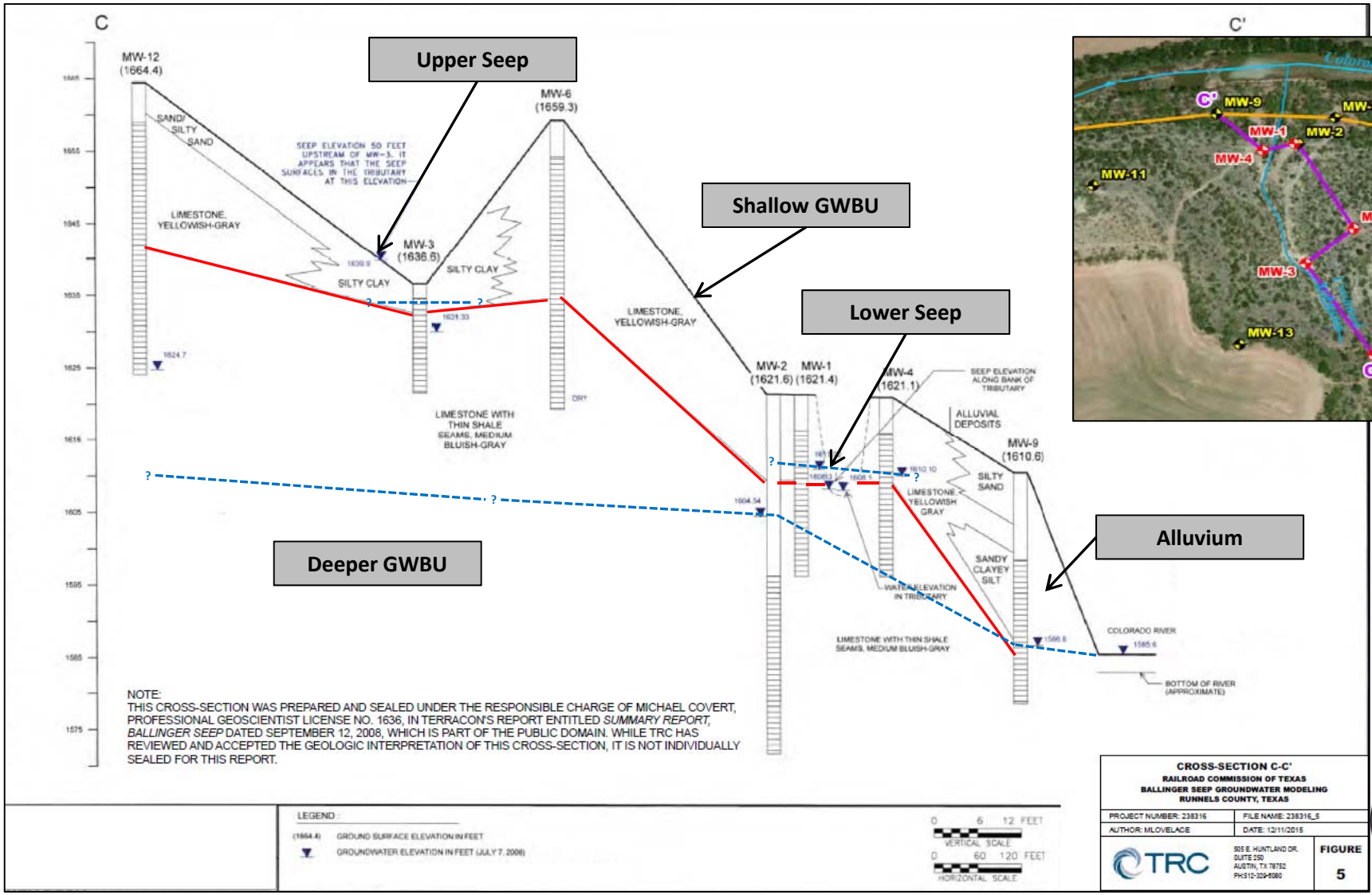
CONCEPTUAL SITE MODEL

- Wolverton-Barr #1 oil well is suspected source of high salinity groundwater (plugged in 1998/2008).
- Lithology consists of two limestone members of the Leuders formation with narrow alluvial bands along the river banks.
- Two groundwater-bearing units (GWBUs).
  - Ephemeral **Shallow GWBU** in upper limestone member; saturated thickness estimated at a few feet; and, limited in areal extent.
  - **Deeper GWBU** in lower limestone member; saturated thickness estimated at 50 feet.

CONCEPTUAL SITE MODEL

- **Primary groundwater flow** – thin shale seams, bedding planes, and fractures
- **Shallow GWBU** – ephemeral, limited in areal extent, and source of seeps along unnamed tributary.
- **Deeper GWBU** – direct connection to river (outcrops in river bed).
- **Alluvium** – ephemeral saturation, limited thickness, and in connection to both Shallow and Deeper GWBUs.
- **Historical maximum chloride concentration in seep** – 58,000 milligrams per liter (mg/L).

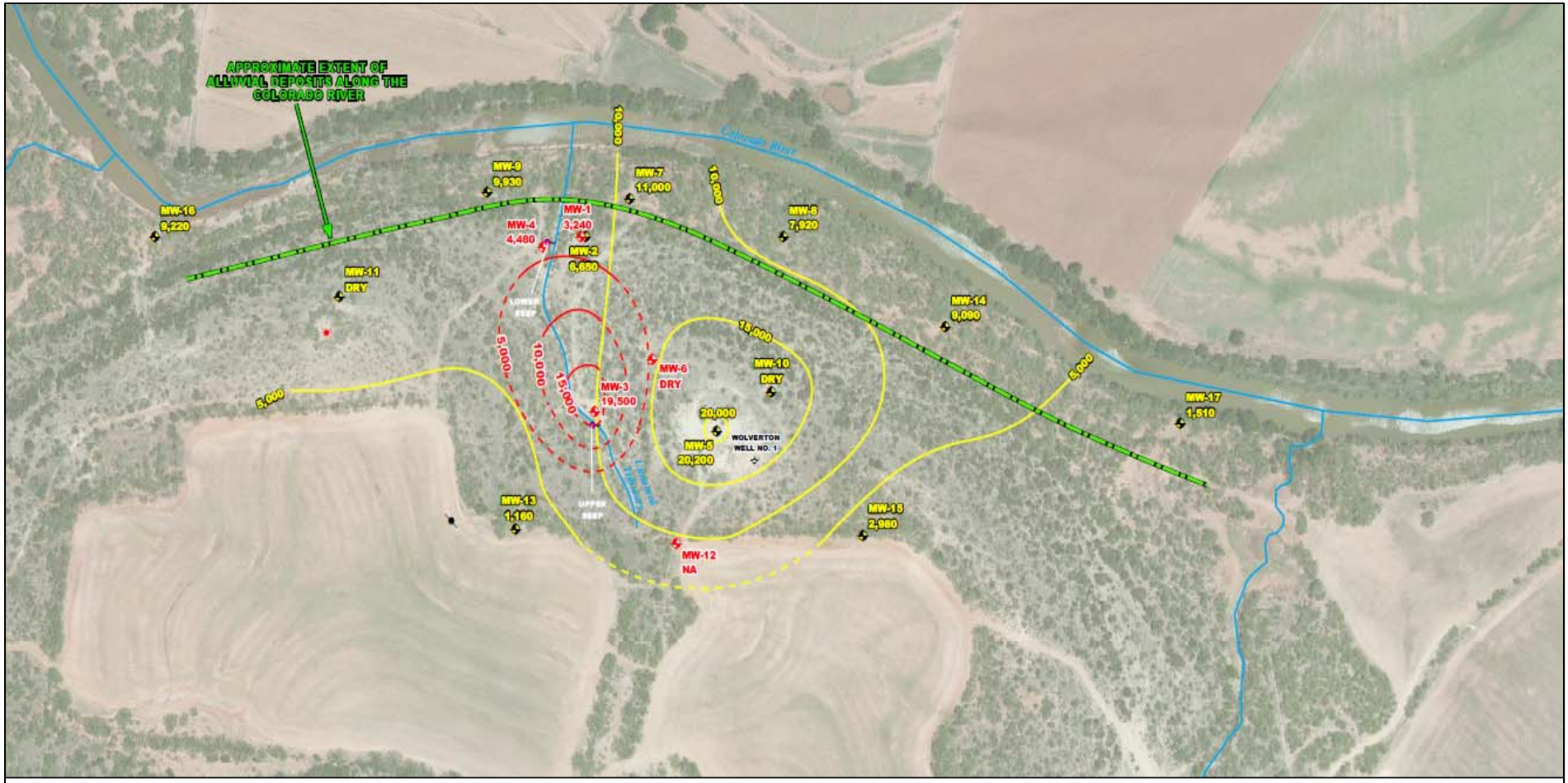
GEOLOGIC CROSS-SECTION



GROUNDWATER AND SURFACE WATER CONDITIONS – JULY 2014

- Groundwater in both GWBUs flows toward the river.
- Maximum chloride concentration in Shallow GWBU at 19,500 mg/L (MW-3).
- Maximum chloride concentration in Deeper GWBU at 20,200 mg/L (MW-5).
- Maximum chloride concentration in the river at 90.2 mg/L (SW-CR-500’ DOWN).
- No surface water present in unnamed tributary (i.e., seeps dry).

GROUNDWATER CONDITIONS
JULY 2014



Legend

- DEEP
- SHALLOW
- DRY HOLE
- SEEP
- PLUGGED OIL WELL
- PLUGGED OIL/GAS WELL
- RIVERS/STREAMS
- NA — MONITORING WELL NOT ANALYZED FOR CHLORIDE
- DRY / DRY — INSUFFICIENT WATER TO SAMPLE - JULY 2014
- 4480 / 9220 — CHLORIDE CONCENTRATOIN (mg/L)
- CHLORIDE CONCENTRATION CONTOUR LINE - DEEP (DASHED WHERE INFERRED)
- CHLORIDE CONCENTRATION CONTOUR LINE - SHALLOW (DASHED WHERE INFERRED)

SOURCES:
1. AERIAL IMAGERY - MICROSOFT AND THEIR DATA PARTNERS.
2. SUMMARY REPORT, BALLINGER SEEP, BALLINGER, RUNNELS COUNTY, TEXAS, TERRACON CONSULTANTS, INC., SEPT. 2008

N

0 125 250
Feet

CHLORIDE CONCENTRATIONS IN GROUNDWATER - JULY 2014

RAILROAD COMMISSION OF TEXAS
BALLINGER SEEP 2014 BMP MONITORING ACTIVITIES
BALLINGER, RUNNELS COUNTY, TEXAS

AUTHOR: MLOVELACE	SAVED: 10/21/2014	MXD: 219393_5

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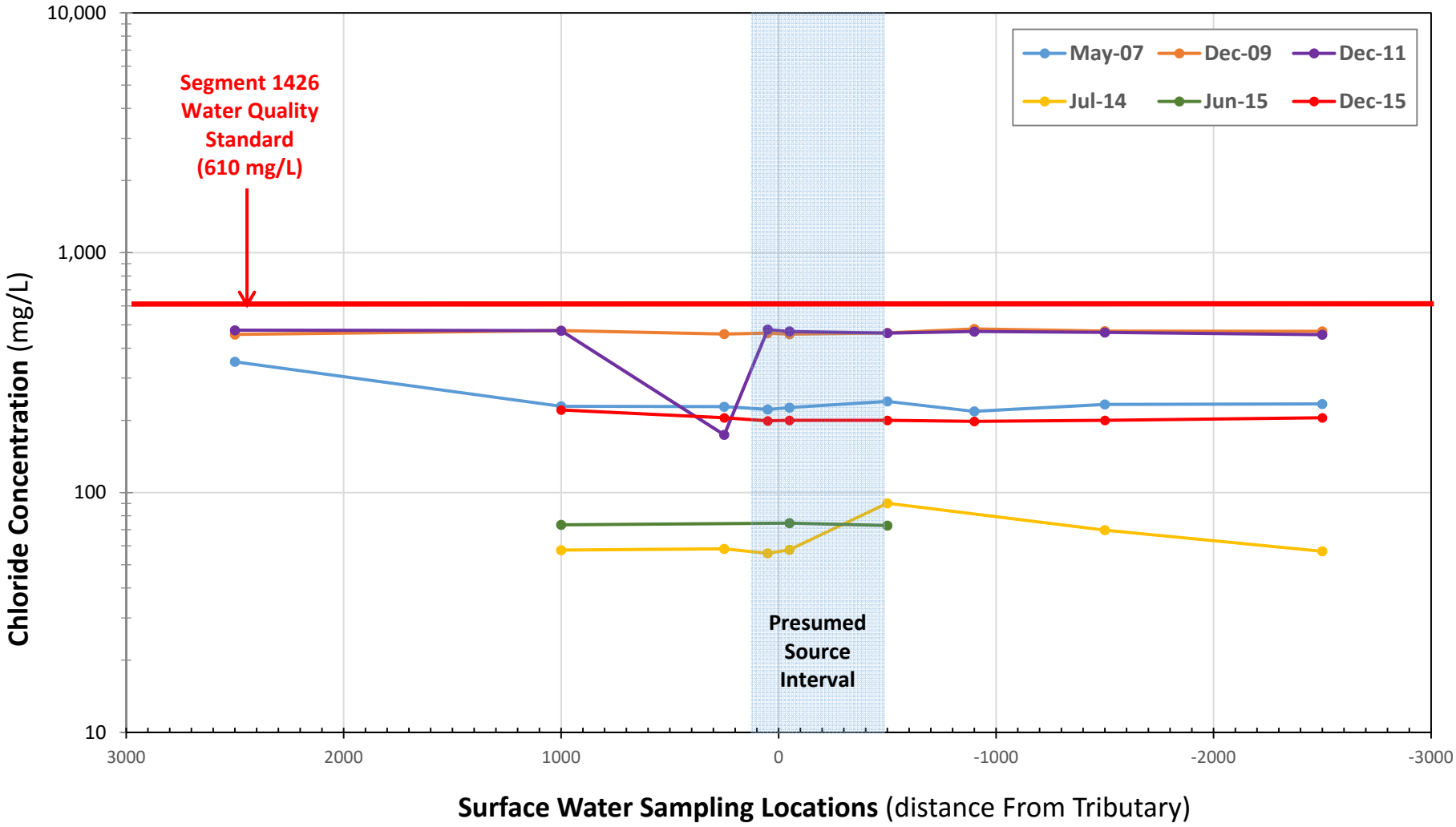
FIGURE 5

SURFACE WATER CONDITIONS
JULY 2014

SURFACE WATER CONDITIONS JUNE AND DECEMBER 2015

- **June 2015** – limited sampling of select stations to support groundwater modeling. Lower tributary had water; upper tributary dry.
- **December 2015** – sampled all river stations and lower tributary stations; upper tributary dry.
- **Maximum chloride concentration in river** – 221 mg/L in December 2015 (SW-CR-1000' UP).
- **Maximum chloride concentrations in tributary** – 2,420 mg/L in December 2015 (SW-TRIB-2).

SURFACE WATER QUALITY TRENDS 2007 – 2015



AQUIFER TESTING

- **Slug testing**:
  - Shallow GWBU wells MW-1, MW-3, and MW-4.
  - Deeper GWBU wells MW-2, MW-7, MW-9, MW-13, and MW-14.
- **Step-drawdown testing**:
  - Shallow GWBU wells MW-3 and MW-4.
  - Deeper GWBU wells MW-7, MW-9, and MW-14.

Testing limited to wells with sufficient water columns.

AQUIFER TESTING

- Hydraulic conductivities (K) from slug testing – ~2E-3 to 6E-6 feet per second (ft/sec).
- K from step-drawdown testing – ~1E-2 to 7E-3 ft/sec.
- Maximum pumping rate during step-drawdown test – 0.1 gallons per minute (gpm) in only one well (MW-9). Well pumped dry in less than 30 minutes.
- All other wells pumped dry at 0.05 gpm during step-drawdown testing at times ranging from 1.5 minutes (Shallow GWBU) to 2.25 hours (Deeper GWBU).

GROUNDWATER MODELING

- MODFLOW for flow modeling and particle tracking.
- Model domain constructed of grid/layers to represent geologic and hydrogeologic characteristics of the site (e.g., two GWBUs).
- Model calibrated to historical groundwater elevation data.
- BMP scenarios evaluated consisted of recovery wells (RW) to intercept high salinity groundwater before discharging to the river.

GROUNDWATER MODELING

- Maximum predicted pumping rate per RW at 0.2 gpm.
- Optimum groundwater recovery configuration estimated with 10 RWs. Two-pronged approach:
  - Six RWs along the river bank to intercept high salinity groundwater before discharge to the river.
  - Four RWs in the center of the shallow and deeper plumes to remove highest chloride concentrations (i.e., source areas).
  - RWs screened through entire saturated thickness of Deeper GWBU.

GROUNDWATER MODELING

- Actual impact of high salinity groundwater to the river is unclear:
  - Samples from river adjacent to site consistently below the water quality standard.
  - Any high salinity groundwater discharging to river appears to have minimal affect on surface water quality.
  - Higher salinity water in tributary not resulting in salinity increases in river.
  - GWBUs do not appear to contain a large volume of water and movement is very slow (e.g., low K).
  - Sustainable RW yield estimated to be very low.

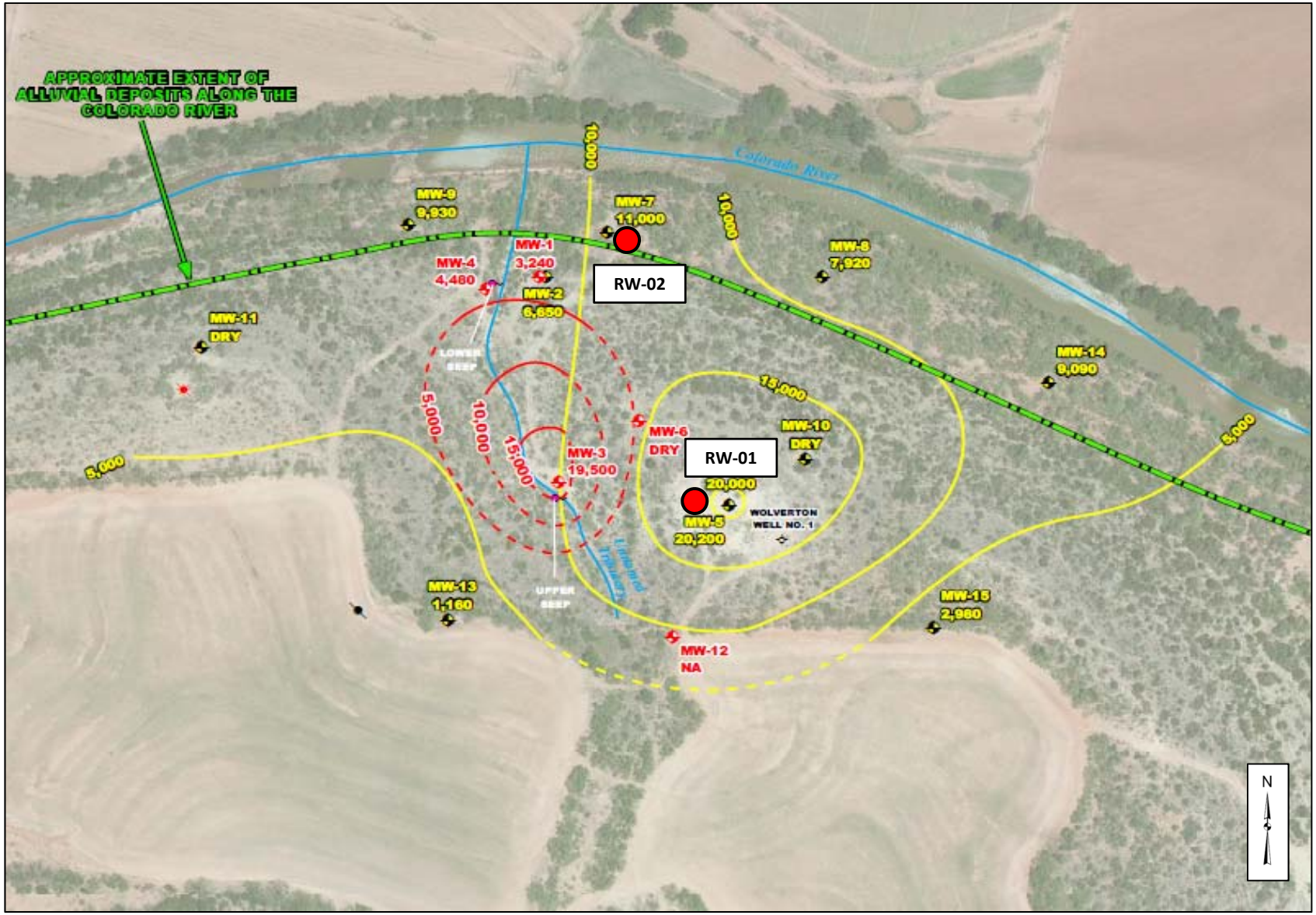
INITIAL BMP DESIGN

- Initial limited scale BMP recommended due to uncertainty regarding actual water quality impacts from groundwater.
- Limited scale BMP will still support salinity load reduction but allows for further assessment of actual aquifer response under continuous pumping conditions.
- Additional surface water and groundwater monitoring recommended to enhance understanding of the groundwater/surface water relationship.

INITIAL BMP DESIGN

- Design Concept
  - Pump groundwater from two RWs.
    - One near confluence of tributary and river to intercept water from the seep/tributary and Deeper GWBU immediately upgradient of the river.
    - One near source to capture the highest portion of the Deeper GWBU plume.
  - Discharge recovered groundwater via aboveground piping to a frac tank for storage.
  - Transport recovered groundwater to offsite RRC-permitted saltwater disposal well.

INITIAL BMP DESIGN



Questions?

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